ESD-TR-80-223

(12)

Quarterly Technical Summary

Advanced Electronic Technology

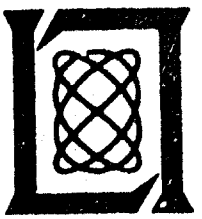
15 November 1980

Prepared for the Department of the Air Force
under Electronic Systems Division Contract F19628-80-C-0002 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS

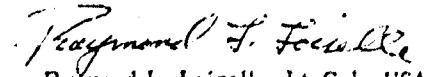


The work reported in this document was performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology, with the support of the Department of the Air Force under Contract F19628-80-C-0002.

The views and conclusions contained in this document are those of the contractor and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the United States Government.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER



Raymond L. Loiselle, Lt. Col., USAF
Chief, ESD Lincoln Laboratory Project Office

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

. AUGUST – 31 OCTOBER 1980

ISSUED 16 JANUARY 1981

LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 August through 31 October 1980. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

CONTENTS

Introduction iii

DATA SYSTEMS — ~~DIVISION 2~~

Introduction 1

Digital Integrated Circuits, Group 23 3

I. Introduction 3

II. MNOS Memory 3

III. Advanced Circuit Design and Simulation 3

IV. Restructurable VLSI Technology 4

V. Semiconductor Processing 5

VI. Device Theory, Test, and Modeling 5

Computer Systems; Group 28 7

SOLID STATE — ~~DIVISION 8~~

Introduction 9

Division 8 Reports on Advanced Electronic Technology 11

I. Solid State Device Research 17

II. Quantum Electronics 17

III. Materials Research 17

IV. Microelectronics, and 18

V. Analog Device Technology 19

DATA SYSTEMS
DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 August through 31 October 1980 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs.

Seismic Discrimination	DARPA/NMRO
Distributed Sensor Networks	DARPA/IPTO
Network Speech Systems Technology	OSD-DCA
Digital Voice Processing	AF/ESD
Digital Voice Interoperability Program	AF/ESD
Packet Speech Systems Technology	DARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Restructurable VLSI	DARPA/IPTO
Multi-Dimensional Signal Processing	AF/RADC

A. J. McLaughlin
Head, Division 2

T. Bially
Associate Head

DIGITAL INTEGRATED CIRCUITS
GROUP 23

I. INTRODUCTION

The first run of CMOS test chips has been processed successfully; extensive testing is under way in order to characterize the process. MNOS 64K-bit memory arrays with yields in the 95 to 98% range have been fabricated and tested.

II. MNOS MEMORY

Several 64K memory chips were produced on which 95 to 98% of the memory array was operational. The computer-controlled memory tester was debugged, and programs written to evaluate the best chips. Write times of 3 μs were used, and the 8-μs read access time at the wafer probe was limited by the off-chip decoding circuits and sense amplifier. Retention measurements on entire memory arrays revealed a fast initial stored-charge loss up to 1 s followed by a much slower charge decay rate up to at least several days. An extrapolated flatband voltage (V_{FB}) window of 2.5 V is obtained after one month storage. A standard deviation of 0.3 V about the mean V_{FB} was measured indicating good uniformity of stored charge. Deep depletion is used to inhibit partial writing on half-selected cells during writing. The most frequent half-select condition was examined and found to produce at most a 0.5-V shift in the stored V_{FB} after 1 hr of continuous disturbing. This disturb is small, but could be further reduced by a slight increase in epitaxial Si thickness or slight reduction in nitride thickness. Read disturbing was performed for 1 hr. No disturb was observed, as expected, since the read operation is performed with relatively small voltages in deep depletion. Since our memory approach emphasizes very high density rather than nonvolatility, refresh cycles are permitted but only at such a rate that power consumption would never become a problem. A 1-hr chip refresh cycle is therefore acceptable and is consistent with retention and write and read disturb data taken to date. Measurements are under way to more fully characterize the 64K memory chips, and results will be documented in a final report.

III. ADVANCED CIRCUIT DESIGN AND SIMULATION

A. Bulk CMOS Test Chip

The many test devices on the first run of CMOS chips have been wafer probed and most perform as predicted. Shift registers, gate chains, and flipflops have been operated successfully. Most defects relate to lithography problems which should be easy to remedy.

B. Scaled NMOS

The first run of scaled NMOS test chips is in process again now that the direct-step-on wafer machine is becoming available for routine use.

C. Thermal Nitride

Thin (100 Å) oxide films nitrided in ammonia at high temperatures have been shown to have a sandwich structure with high nitride compositions on the outside and at the silicon interface and

almost pure oxide in the center.* Experiments are in process to characterize the formation rates of the nitride layers. The interface electrical properties are functions of the degree of nitridation of the interface, and it has been shown that sintering the aluminum gates causes a positive shift of the flatband voltage, even to the point of generating negative interface charge; it is hoped this process can be "tuned" to adjust the interface properties.

IV. RESTRUCTURABLE VLSI TECHNOLOGY

A. Laser-Formed Vias

We continue to explore the programming technique for RVLSI which uses laser-formed interconnections between two levels of isolated but overlapping metal lines.†

Our previous work employed a commercial I.C. mask trimmer with a Nd-YAG laser as the light source. Using 100-ns-long pulses, with peak power in the 2.2-kW range, successful connections were made with a single pulse impinging on a multilayered sandwich structure [1 μm of base thermal oxide, followed by a first-level metal (0.5 μm aluminum alloy), a second-level insulating layer (0.2 to 1.0 μm of amorphous Si or CVD SiO_2), and topped by a second-level metal (0.5 μm of aluminum)]. Contact resistances of less than 3 ohms were obtained for all connections produced above a threshold laser power level. By using base oxides greater than 5000 Å, diode contacts to the substrate at high laser power levels were successfully eliminated. Unfortunately, SEM photographs of all via connections showed the contact hole surrounded by a web of filaments produced by the explosive nature of this short-pulse process.

The presence of this splattered material led us to investigate a lower peak power level (5 to 10 W) with a longer pulse (5 ms) using a mechanically shuttered CW argon laser. Electrically, these contacts behaved similarly to those generated by the Nd-YAG laser. However, the SEM pictures showed no filaments, with only a smooth ring-shaped wall surrounding the contact crater, an indication of a less violent reaction.

The fact that both procedures produced useful contacts suggests the wide range of processes which can operate to yield laser connections. Current work is concentrated on the splatter-free argon-pulse system.

B. X-Y Positioning Table

A wafer positioning table for laser restructuring has been designed and built. The table uses DC stepping motors to travel over the complete area in steps of 3 μm in both the X and Y directions. A controller is being designed to automate the process.

C. Restructurable VLSI Test Circuit

Design has been started to provide a preliminary demonstration of laser-programmed links in a large-area restructurable VLSI circuit. This circuit will be built on the gate array included on the bulk CMOS test wafer now being processed. The CMOS gate arrays will be customized to form multiple copies of a basic cell. Laser-programmed vias and interconnect metal will be routed in a regular pattern over the wafer in the areas around the gate array now occupied by

---

*M. L. Naiman et al., "Properties of Thin Oxynitride Gate Dielectrics Produced by Thermal Nitridation of Silicon Dioxide," presented at IEEE International Electron Devices Meeting, Washington, D.C., 8-10 December 1980.

†J. I. Raffel et al., "Laser Programmed Vias for Restructurable VLSI," presented at IEEE International Electron Devices Meeting, Washington, D.C., 8-10 December 1980.

test devices and circuits. After the gate arrays have been individually tested, 16 good arrays will be interconnected on the wafer by laser programming to form a complete subsystem. This feasibility test will be a precursor for the DARPA-sponsored spread-spectrum integrator chip.

V. SEMICONDUCTOR PROCESSING

A. Lithography

The direct-step-on wafer projection printer is being integrated gradually into the photolithography processing. While good line width resolution has been obtained, machine stability and level-to-level misalignment have presented difficulties.

B. Polyimide as an Ion Implant Mask

Polyimide is being investigated as an ion implant mask and shows the same stopping power as positive photoresist without thermal deformation even at ten times the ion current possible with photoresist. If the polyimide can be conveniently stripped after implant, the previously demonstrated capability of etching 0.2-μm slots in 1.5-μm-thick layers will make it a very high resolution masking material for VLSI.

VI. DEVICE THEORY, TEST, AND MODELING

A. CMOS Design Rule Checks

The problem of geometrical design rule checks becomes more difficult as the chip size increases. For our CMOS process, there are 52 rule checks which must be performed on thousands of devices whose component parts are found on nine different mask levels. Manual scanning under such conditions is impractical. Consequently, a computer program has been written which employs the Mask Design Rule Checking, MDRC, system to check our CMOS layouts.* The program must first determine which mask provides the definitive boundary for each device, e.g., N-regions, P-regions, N-inserts, P-inserts, N-transistors, P-transistors, etc. The output of the test program, written on magnetic tape, consists of plots of each of the individual device categories and a plot for each type of design-rule violation. Some P-island and poly spacing errors were found on the first mask set design. The program requires about 20 min. of CPU time on the Amdahl 470/V7 to check the CMOS mask set. Since the number of design-rule errors on a real mask set is likely to be small, it was necessary to design a test mask set to debug the checker. This set is a 50-element CMOS array which contains one rule violation in each cell. Both the test array and the rule checking program are being improved as we gain experience with the system.

B. Process Reporter Program

PROREP is a program to report the status of wafer runs, tracking them through the various fabrication steps. An initial version is now operational on the AMDAHL machine, under VM.

Using the DEFINE command, a user enters into the system a wafer-run definition which consists of global information and the process steps. Global information includes wafer ID, status, priority, technology, date, and comment. Process step definitions for each step include the

---

* A. J. Giovinazzo, "A Mask Design Rule Checking System," Proc. IEEE International Conf. on Circuits and Computers, Port Chester, New York, 1-3 October 1980, Vol. II, p. 932.

process name, status, date, and comment. When a wafer-run process step is completed, the wafer definition is updated to reflect this change. The program produces run location sheets similar to those now being produced manually and also on-line information previously not available. A password scheme is employed to limit write access to the files.

C. Photodepopulation Spectroscopy of MNOS Diodes

Photodepopulation spectroscopy of MNOS diode devices in which negative charge has been stored indicates there are two trap levels in the nitride gap that are associated with the negative charge. These levels are presumably the nitride electron traps. Photodepopulation spectroscopy of MNOS diode devices in which positive charge has been stored is being done in an attempt to identify hole trap levels in the nitride gap.

COMPUTER SYSTEMS
GROUP 28

An IBM 3277 Graphics Attachment was installed during the quarter. This equipment combines a high-speed alphanumeric display terminal with a vector-writing storage tube to provide a powerful interactive graphics system. The IBM 3277 terminal, which has been in use at the Laboratory for some time, is capable of data transmission at 1.2 Mbps, but is limited to handling alphanumeric information. The Tektronix 4000 series storage-tube terminal, also in use for some time, is capable of both alphanumeric and vector displays, but is limited to data rates of only 4800 bps on the Lincoln system. A further limitation of the Tektronix is that it must function successively as both an interactive terminal and a graphics display.

The Graphics Attachment fits between the IBM 3277 terminal and a Tektronix storage tube. This means that the display system gains the advantage of the 1.2-megabit transfer rate for graphic output. The 3277 communicates with the central computer system as usual to control the processing. Graphic output data, however, is passed through the 3277 to the Graphics Attachment where it is converted to vector form to drive the Tektronix display terminal. The 3277 controls the operation while the Tektronix is free to function as a high-speed graphic output device. Supporting software for both the Laboratory's graphics package, GRLL, and for APL has been developed.

The inevitable expansion of the ARPA Network has required an enlarged addressing capability. A new 32-bit format has been mandated. A limited, but workable, mechanism has been installed in the Lincoln host software to handle the new format. Work is in progress on a more general capability along with consideration of a rewrite of the ten-year-old code. Since Lincoln is the only current node using the VM/370 Operating System, inquiries have been received from prospective new users who also intend to run under VM/370.

Minor hardware changes during the quarter involved the conversion of two seven-track tape drives to nine track and the addition of two spindles (634 megabytes) of direct-access storage. The system now includes over six gigabytes of disk file storage, 26 tapes, and more than 400 user terminals. Further additions to each of these three subsystems are in progress.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 August through 31 October 1980. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, DARPA, Navy, NASA, and DOE.

A. L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 August through 15 November 1980

PUBLISHED REPORTS

Journal Articles

JA No.			
5026	Collision Narrowing of HF Fundamental Band Spectral Lines by Neon and Argon	A. S. Pine	J. Mol. Spectrosc. 82, 435 (1980)
5040	The Effect of Implant Temperature on the Electrical Characteristics of Ion Implanted Indium Phosphide	J. P. Donnelly C. E. Hurwitz	Solid-State Electron. 23, 943 (1980)
5072	Photo-Acoustic and Photo-Refractive Detection of Small Absorptions in Liquids	S. R. J. Brueck H. Kildal L. J. Belanger	Opt. Commun. 34, 199 (1980)
5075	Picosecond Optical Sampling	H. A. Haus* S. T. Kirsch* K. Mathyssek* F. J. Leonberger	IEEE J. Quantum Electron. QE-16, 870 (1980)
5096	Atomic Resonance-Line Lasers for Atomic Spectrometry	D. J. Ehrlich R. M. Osgood, Jr. G. C. Turk* J. C. Travis*	Anal. Chem. 52, 1354 (1980)
5100	Radiometric Observations of the 752.033-GHz Rotational Absorption Line of H_2O from a Laboratory Jet	G. F. Dionne J. F. Fitzgerald T-S. Chang M. M. Litvak* H. R. Fetterman	Intl. J. Infrared and Millimeter Waves 1, 581 (1980)
5103	Remote Sensing of NO Using a Differential Absorption Lidar	N. Menyuk D. K. Killinger W. E. DeFeo	Appl. Opt. 19, 3282 (1980)
5109	Crystallization-Front Velocity During Scanned Laser Crystallization of Amorphous Ge Films	R. L. Chapman J. C. C. Fan H. J. Zeiger R. P. Gale	Appl. Phys. Lett. 37, 292 (1980)
5115	Surface Passivation Techniques for InP and InGaAsP p-n Junction Structures	V. Diadiuk C. A. Armiento S. H. Groves C. E. Hurwitz	IEEE Electron. Devices Lett. EDL-1, 177 (1980)

* Author not at Lincoln Laboratory.

JA No.

5116	Arsenic Stabilization of InP Substrates for Growth of $Ga_xIn_{1-x}As$ Layers by Molecular Beam Epitaxy	G. J. Davies* R. Heckingbottom* H. Ohno* C. E. C. Wood* A. R. Calawa	Appl. Phys. Lett. 37, 290 (1980)
5121	High-Efficiency InP Homojunction Solar Cells	G. W. Turner J. C. C. Fan J. J. Hsieh	Appl. Phys. Lett. 37, 400 (1980)
5132	Liquidus Isotherms, Solidus Lines and LPE Growth in the Te-Rich Corner of the Hg-Cd-Te System	T. C. Harman	J. Electron. Mater. 9, 945 (1980)

Meeting Speeches

MS No.

4967B	Graphoepitaxy	D. C. Flanders	J. Vac. Sci. Technol. 17, 1195 (1980)
5268	Wide-Bandwidth CO_2 Laser Photomixers	D. L. Spears	Proc. SPIE Vol. 227: CO_2 Laser Devices and Applications (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1980), pp. 108-116
5271	Vapor-Phase Epitaxy of InP and GaInAsP	P. Vohl	Proc. 1980 NATO-sponsored InP Workshop, Harwichport, Massachusetts, 17-19 June 1980, pp. 305-311
5277	Far Infrared Heterodyne Systems	P. E. Tannenwald	Proc. Intl. Conf., Williamsburg, Virginia, 25-27 March 1980, Heterodyne Systems and Technology, Part II, (NASA Conference Publication 2138)
5285	Synthesis and Crystal Growth of InP	G. W. Iseler	Proc. 1980 NATO-sponsored InP Workshop, Harwichport, Massachusetts, 17-19 June 1980, pp. 99-104
5312	Extending the Operating Temperature, Wavelength and Frequency Response of HgCdTe Heterodyne Defectors	D. L. Spears	Proc. Intl. Conf., Williamsburg, Virginia, 25-27 March 1980, Heterodyne Systems and Technology, Part II (NASA Conference Publication 2138), pp. 309-325
5345	Detectors for the 1.1-1.6 μm Spectral Region	C. E. Hurwitz	Proc. SPIE Vol. 224: Fiber Optics for Communications and Control (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1980), pp. 122-127

* Author not at Lincoln Laboratory.

UNPUBLISHED REPORTS

Journal Articles

JA No.			
5071	Phase Diagram for LPE Growth of GaInAsP Layers Lattice-Matched to InP Substrates	J. J. Hsieh	Accepted by IEEE J. Quantum Electron.
5120	Avalanche Multiplication and Noise Characteristics of Low Dark-Current GaInAsP/InP Avalanche Photodetectors	V. Diadiuk S. H. Groves C. E. Hurwitz	Accepted by Appl. Phys. Lett.
5124	Paramagnetic-Ion Crystalline Lasers	P. F. Moulton	To be published in Handbook Series on Laser Science Volume 1: Lasers in All Media (CRC Press, Boca Raton, Florida)
5127	Heteroepitaxy of $Ge_{1-x}Si_x$ on Si by Transient Heating of Ge-Coated Si Substrates	J. C. C. Fan R. P. Gale F. M. Davis G. H. Foley	Accepted by Appl. Phys. Lett.
5129	A Comparison of Flash-Lamp-Excited $Nd_xLa_{1-x}P_5O_{14}$ (x = 1.0, 0.75, 0.20) Lasers	S. R. Chinn W. K. Zwicker*	Accepted by J. Appl. Phys.
5136	Submillimeter Heterodyne Detection of Interstellar CO at 434 μm	H. R. Fetterman G. A. Koepf* P. F. Goldsmith* B. J. Clifton D. Buhl* N. R. Erickson* D. D. Peck N. McAvoy* P. E. Tannenwald	Accepted by Science
5140	A Balloon-Borne Laser Heterodyne Radiometer for Measurements of Stratospheric Trace Species	R. T. Menzies* C. W. Rutledge* R. A. Zanteson* D. L. Spears	Accepted by Appl. Opt.
5144	Low Dark-Current, High-Gain, GaInAsP/InP Avalanche Photodetectors	V. Diadiuk S. H. Groves C. E. Hurwitz G. W. Iseler	Accepted by IEEE J. Quantum Electron.
5150	Gain Spectra in GaInAsP/InP Proton-Bombarded Stripe-Geometry DH Lasers	J. N. Walpole T. A. Lind J. J. Hsieh J. P. Donnelly	Accepted by IEEE J. Quantum Electron.

* Author not at Lincoln Laboratory.

JA No.			
5163	Efficient Si Solar Cells by Laser Photochemical Doping	T. F. Deutsch J. C. C. Fan G. W. Turner R. L. Chapman D. J. Ehrlich R. M. Osgood, Jr.	Accepted by Appl. Phys. Lett.
5167	Spectral Characteristics of External-Cavity-Controlled Semiconductor Lasers	M. W. Fleming A. Mooradian	Accepted by IEEE J. Quantum Electron.
5174	Liquid-Phase Epitaxial Growth of InP and InGaAsP Alloys	S. H. Groves M. C. Plonko	Accepted by J. Cryst. Growth
5175	Synthesis and Crystal Growth of InP	G. W. Iseler	Accepted by J. Cryst. Growth
5176	Vapor-Phase Epitaxy of GaInAsP and InP	P. Vohl	Accepted by J. Cryst. Growth
5178	Laser Microchemistry: Applications in Semiconductor Processing	T. F. Deutsch R. M. Osgood, Jr. D. J. Ehrlich	Accepted by Physics News

Meeting Speeches*

MS No.			
4530E	High-Resolution Molecular Spectroscopy Using a Tunable Difference-Frequency Laser System	A. S. Pine	1980 Annual Mtg. Optical Society of America, Chicago, Illinois, 13-17 October 1980
5053B	Wideband SAW Fourier-Transform Processor Design and Applications	R. C. Williamson	Seminar, General Electric, Syracuse, New York, 24 September 1980
5236B, D,E	Laser-Induced Photochemical Reactions for Electronic-Device Fabrication	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Symposium Allied Chemical, Morristown, New Jersey, 2 October 1980; Seminar, Raytheon, Waltham, Massachusetts, 22 October 1980; Bell Laboratories, Holmdel, New Jersey, 5 November 1980
5236C	Direct-Write Laser Processing for Microelectronics	R. M. Osgood, Jr. D. J. Ehrlich T. F. Deutsch	VLSI Symposium, M.I.T., 7 October 1980
5248A	Acoustoelectric Signal-Processing Technology	R. W. Ralston	Global Positioning Satellite Seminar, Dayton, Ohio, 8 October 1980

* Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

MS No.			
5278A, D	Silicon Graphoepitaxy	M. W. Geis D. A. Antoniadis D. J. Silversmith R. W. Mountain H. I. Smith	12th Conf. on Solid State Devices, Tokyo, Japan, 26 August 1980; 27th National Vacuum Symp. Detroit, Michigan, 14-17 October 1980
5278E	Graphoepitaxy of Silicon	M. W. Geis	Seminar, IBM, Yorktown Heights, New York, 19 August 1980
5358A, C	The CLEFT Process: A Technique for Producing Epitaxial Films on Reusable Substrates	J. C. C. Fan C. O. Bozler R. W. McClelland	Materials and Techniques for Photovoltaics Symp., Hollywood, Florida, 5-10 October 1980; Conf. on High Efficiency Solar Cell and Radiation Damage, Cleveland, Ohio, 15-17 October 1980
5358B	The CLEFT Process: A Peeled Film Technique	C. O. Bozler R. W. McClelland J. C. C. Fan	1980 International Symposium on Gallium Arsenide and Related Compounds, Vienna, Austria, 22-24 September 1980
5364	Reactive Ion Etching in the Fabrication of Niobium Tunnel Junctions	S. A. Reible	1980 Applied Superconductivity Conference, Santa Fe, New Mexico, 29 September 1980
5379	Atomic Resonance-Line Lasers: New Sources for Analytical Spectrometry	D. J. Ehrlich R. M. Osgood, Jr. G. C. Turk* J. C. Travis*	7th Annual Mtg., Federation of Analytical Chemistry and Spectroscopy Societies, Philadelphia, Pennsylvania, 28 September 1980
5464	Submillimeter Heterodyne Detection of Molecular Emission	H. R. Fetterman	1980 Annual Mtg., Optical Society of America, Chicago, Illinois, 14-17 October 1980
5478	Submicrometer Structures	H. I. Smith	Intl. Conf. on Microlithography, Amsterdam, The Netherlands, 30 September 1980
5488	Lateral Epitaxial Overgrowth of Silicon on SiO_2	D. D. Rathman D. J. Silversmith	Electrochemical Society Mtg., Hollywood, Florida, 6-10 October 1980
5498, A	On the Use of Arsine in the MBE Growth of GaAs	A. R. Calawa	Varian MBE-Users' Seminar, Palo Alto, California, 25 October 1980; 2nd Annual MBE Workshop, Cornell University, Ithaca, New York, 22 October 1980

* Author not at Lincoln Laboratory.

MS No.			
5509	Temporal Correlation Measurements of Pulsed Dual CO_2 LIDAR Returns	N. Menyuk D. K. Killinger	10th Intl. Laser Radar Conf. Silver Springs, Maryland, 6-9 October 1980
5510	CO_2 Laser Remote Sensing of Atmospheric CO, NO, and Ethylene	D. K. Killinger N. Menyuk	IRIS Specialty Group on Active Systems, MITRE Corporation, Bedford, Massachusetts, 28-29 October 1980
5511	The Role of Surface-Acoustic-Wave Devices in Electronic Signal Processing	E. Stern	Electronics and Aerospace Systems Conf., Arlington, Virginia, 29 September 1980
5528	CLEFT – A Process for Producing Transferable Single-Crystal Semiconductor Films	C. O. Bozler	Seminar, RCA Laboratories, Princeton, New Jersey, 16 October 1980

SOLID STATE DIVISION, 8

I. SOLID STATE DEVICE RESEARCH

Low-loss GaAs semiconductor optical waveguides have been formed by the lateral epitaxial growth of single-crystal GaAs over SiO_2. Single-mode rib waveguides have exhibited losses of only 2.3 dB/cm, which are 2 to 3 dB/cm lower than those generally reported for GaAs optical waveguides. Furthermore, the guides should have smaller allowable bend radii (<1 mm) than previously reported guides and could form the basis of a new class of guided-wave structures.

The gain spectra for TE polarization in a GaInAsP/InP laser have been measured as a function of DC bias current below laser threshold. The results have been used to relate the maximum net gain to the nominal current density and radiative quantum efficiency, yielding coefficients important for the optimization of laser design.

High-quality n^+-InP layers over InGaAs have been grown from Sn solutions. The technique is generally applicable to the growth of an alloy of very low As content over one of high As content. The ability to grow these layers may facilitate the fabrication of improved InGaAs lasers and detectors operating at 1.55 μm.

II. QUANTUM ELECTRONICS

A study of the effect of averaging over a large number of pulses indicates that improvement in signal-to-noise ratio in a LIDAR system is limited by statistical variations due to atmospheric turbulence. This has motivated construction of a dual CO_2 differential-absorption system. Initial temporal correlation studies with this system have been made using various targets.

The spectral width of a GaAlAs CW single-mode diode laser has been shown to vary linearly with reciprocal output power at 300 K with a slope 50 times greater than predicted by the Schawlow-Townes expression without the partial inversion factor. Spectral narrowing observed at 77 K for constant mode power is consistent with the predicted temperature dependence of the partial inversion factor.

A program to apply the techniques of nonlinear spectroscopy to diagnostic problems in semiconductors has been initiated. Preliminary results of CARS measurements of phonons and plasmons in a number of semiconductor materials have been obtained.

Liquid N_2 Raman laser characteristics in both tight focusing and collimated-beam geometries have been investigated. A quantum conversion efficiency of 92% into the first Stokes output has been observed for the collimated-beam geometry.

Using molecular beams and a tunable submillimeter laser sideband spectrometer, sub-Doppler linewidth rotational transitions at 700 GHz have been observed for the first time. The separation between two closely spaced CH_3F lines has been measured to an accuracy of 70 kHz.

III. MATERIALS RESEARCH

It has been demonstrated that under suitable experimental conditions the deposition rate of InP layers grown by vapor-phase epitaxy varies significantly with crystallographic orientation, and this orientation dependence has been utilized to obtain structures in which single-crystal InP layers are grown laterally over phosphosilicate-glass films. Structures of this type are of potential interest as waveguides for infrared radiation in integrated optical circuits.

Since amorphous films in the Ge-Si alloy system, as well as films which have undergone amorphous-to-crystalline transitions, have potential applications in solar cells and other devices, differential scanning calorimetry has been used to measure the transition temperature (T_t) and latent heat of crystallization (ΔH) for $Ge_{1-x}Si_x$ films covering the entire composition range from Ge to Si. The measured values of T_t and ΔH (per gram) increase linearly with x.

Heteroepitaxial Ge films have been grown by solid-phase epitaxy (SPE) on single-crystal ⟨100⟩ Si substrates and then treated by ion implantation and reannealing to reduce their twin density. Heteroepitaxial GaAs layers of good crystal quality have been grown by chemical vapor deposition on the reannealed Ge films, indicating that it should be possible to use SPE-Ge/Si substrates in the fabrication of low-cost, high-efficiency GaAs thin-film solar cells.

IV. MICROELECTRONICS

The low-light-level characterization of the 100- × 400-element CCD imager being built for the GEODSS (Ground-based Electro-Optical Deep Space Surveillance) Program has continued. Charge transfer inefficiency of 1.2×10^{-4} per transfer has been measured for charge packets of about 100 electrons, and for larger charge packets a value of less than 1×10^{-5} per transfer has been measured for packets up to 500,000 electrons. Low-light-level operation of the device has revealed a heretofore unobserved trapping mechanism in isolated CCD wells.

Long-term anneals in a hydrogen ambient at temperatures compatible with aluminum metallization (<500°C) have proven effective in removing surface states at the SiO_2-Si interface in dual-dielectric (Si_3N_4 over SiO_2) gate structures where the Si_3N_4 acts as a diffusion barrier to the hydrogen. The annealing takes place by lateral diffusion of hydrogen through the SiO_2 under the Si_3N_4, and is initiated at the periphery of the device at openings in the Si_3N_4 layer. Rate measurements of this process made on the GEODSS imager using video techniques are in agreement with published results.

Variations in input-gate capacitance and threshold voltage among the multiple inputs of the previously reported CCD programmable transversal filter structures limit the dynamic range and bit accuracy of these devices. The current CCD fabrication process has reduced the relative input-gate capacitance variation to less than 1% on a typical device, and by eliminating the boron offset implant under the surface channel input gates, the threshold voltage variation has been reduced to a 1σ value of 2 mV.

A technique has been developed for integrating Schottky-barrier mixer diodes and FETs in a monolithic GaAs receiver for operation at 31 GHz. For IFs between 2.0 and 2.3 GHz, the conversion gain and noise figure are approximately 4 and 11.5 dB, respectively. Measurement and analysis indicate that with improved matching and two IF amplifier stages a noise figure below 10 dB and a conversion gain of 14 dB can be achieved.

An all-polyimide mask for the proton exposure of resists has been developed, and a resolution of 1.2 μm has been demonstrated with a grating pattern of 1.2-μm lines on 3.8-μm centers. The mask consists of a freestanding polyimide membrane about 2 μm thick with the pattern etched into the membrane to a depth of 1 μm by oxygen reactive-ion etching.

The crystallographic and electrical properties of graphoepitaxial silicon films in which the crystallization was induced with a strip-heater oven have been measured and compared with the properties of graphoepitaxial silicon films in which the crystallization was induced with a scanning laser. The range of orientations of the crystallites in the silicon was considerably reduced for the strip-heater-oven crystallized films. FETs fabricated in oven-crystallized

silicon have surface mobilities between 300 and 460 $cm^2/V\text{-}s$, while similar devices could not be fabricated in laser-crystallized films because of surface microcracks.

V. ANALOG DEVICE TECHNOLOGY

A wideband, low-loss, temperature-stable matched filter has been developed using surface-acoustic-wave (SAW) reflective-array-compressor (RAC) technology. This device is fabricated on a special cut of quartz. It has a time-bandwidth (TB) product of 1900, which is comparable with TB products achieved with conventional $LiNbO_3$, but with a temperature stability about 100 times better than $LiNbO_3$ RACs. The quartz RAC incorporates both edge-bonded transducers to achieve 40% fractional bandwidth and beam-steering compensation in the etched reflection gratings to achieve 38-μs dispersion.

Controllable attenuation of SAWs on $LiNbO_3$ has been accomplished by using resistive cermet films. Attenuation varying from 0.06 to 0.4 dB/wavelength at 300 MHz was obtained by using sputtered 70% Cr_2O_3 – 30% Cr films about 1000 Å thick. These rugged and stable films have been used in RAC devices as a contaminant-free method of suppressing edge reflections in order to eliminate spurious responses. Such films appear appropriate to trim the amplitude response of RACs as well.

A hybrid analog/binary signal-processing technique has been developed which offers 40 to 60 dB of processing gain for spread-spectrum communication and wideband radar systems. The hybrid approach is a generic concept which very effectively combines the attributes and compensates for the limitations of the separate techniques alone. Hybrid processing can be implemented with several technologies. A preliminary demonstration employing SAW convolvers with Si integrated circuits has provided the expected 46-dB signal-processing gain.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: ESD-TR-80-223	2. GOVT ACCESSION NO.: AD-A097023
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: Advanced Electronic Technology	5. TYPE OF REPORT & PERIOD COVERED: Quarterly Technical Summary rept. 1 August – 31 October 1980
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Alan J. McLaughlin and Alan L. McWhorter	8. CONTRACT OR GRANT NUMBER(s): F19628-80-C-0002
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Lincoln Laboratory, M.I.T. P.O. Box 73 Lexington, MA 02173	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Element No. 63250F Project No. 649L
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Systems Command, USAF Andrews AFB Washington, DC 20331	12. REPORT DATE: 15 November 1980
	13. NUMBER OF PAGES: 24
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*: Electronic Systems Division Hanscom AFB Bedford, MA 01731	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

digital computers	solid state devices	quantum electronics
integrated circuitry	materials research	microelectronics
computer systems	laser research	analog device technology

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This Quarterly Technical Summary covers the period 1 August through 31 October 1980. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

207650

JRB